Redox

Question Paper 3

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Electrochemistry
Sub-Topic	Redox
Paper Type	Theory
Booklet	Question Paper 3

Time Allowed: **83 minutes**

Score: **/69**

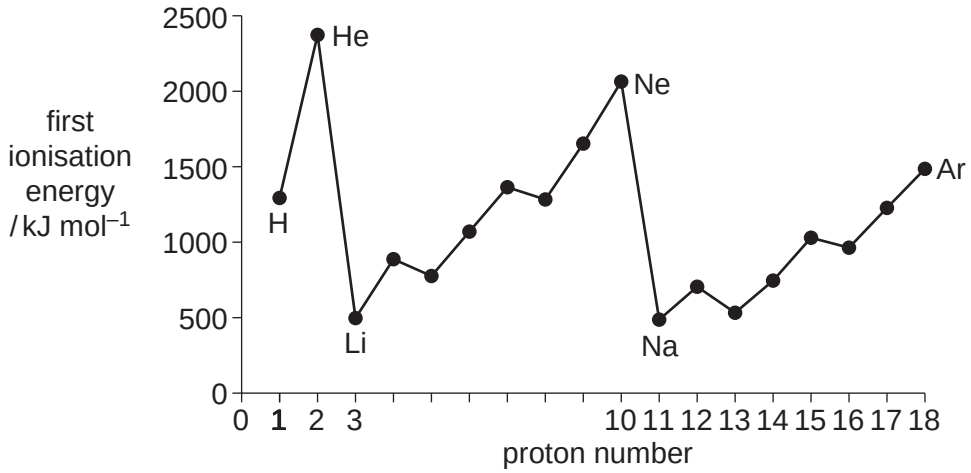
Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 The Periodic Table we currently use is derived directly from that proposed in 1869 by Mendeleev who had noticed patterns in the physical and chemical properties of the elements he had studied.

The diagram below shows the first ionisation energies of the first 18 elements of the Periodic Table.



(a) Give the equation, including state symbols, for the first ionisation energy of carbon.

..... [2]

(b) **(i)** Explain why sodium has a lower first ionisation energy than magnesium.

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(ii) Explain why magnesium has a higher first ionisation energy than aluminium.

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(iii) Explain why helium, He, and neon, Ne, occupy the two highest positions on the diagram.

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(iv) Explain why the first ionisation energy of argon, Ar, is lower than that of neon, which is lower than that of helium.

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[8]

(c) **(i)** The first ionisation energies of the elements Na to Ar show a variation. Some physical properties show similar variations.

The atomic radius of the elements decreases from Na to C*l*.

Give a brief explanation of this variation.

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(ii) The cations formed by the elements Na to A*l* are smaller than the corresponding atoms.

Give a brief explanation of this change.

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[3]

(d) The oxides of the elements of the third Period behave differently with NaOH(aq) and HC*l* (aq). In some cases, no reaction occurs.

Complete the table below by writing a balanced equation for any reaction that occurs, with heating if necessary. If you think no reaction takes place write 'no reaction'.

You do not need to include state symbols in your answers.

.....MgO(s)		..... NaOH (aq)	→	
.....MgO(s)		..... HC*l* (aq)	→	
.....Al_2O_3(s)		..... NaOH (aq)	+ .....H_2O (l)	→
.....Al_2O_3(s)		..... HC*l* (aq)	→	
.....SO_2(g)	+	..... NaOH (aq)	→	
.....SO_2(g)	+	..... HC*l* (aq)	→	

[6]

[Total: 19]

2 **(a)** The Group IV oxides CO_2 and SiO_2 differ widely in their physical properties. Describe these differences and explain them in terms of their structure and bonding.

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..... [3]

(b) What are the properties of a *ceramic* material? Why is silicon(IV) oxide very suitable as a component of ceramics?

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..... [2]

(c) Lead(II) oxide reacts with both acids and bases.

(i) What is the name given to oxides that have this property?

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(ii) Write a balanced equation for the reaction between PbO and NaOH.

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[2]

(d) Tin forms an oxide, **A**, that contains the metal in both oxidation states II and IV. The formula of **A** can be found by the following method.

- A sample of **A** was dissolved in $H_2SO_4(aq)$, producing solution **B**, which was a mixture of tin(II) sulfate and tin(IV) sulfate.
- A 25.0 cm^3 sample of solution **B** was titrated with 0.0200 mol dm^{-3} $KMnO_4$. 13.5 cm^3 of $KMnO_4$ was required to reach the end-point.
- Another 25.0 cm^3 sample of solution **B** was stirred with an excess of powdered zinc. This converted all the tin into tin(II). The excess of zinc powder was filtered off and the filtrate was titrated with 0.0200 mol dm^{-3} $KMnO_4$, as before. This time 20.3 cm^3 of $KMnO_4$ was required to reach the end-point.

The equation for the reaction occurring during the titration is as follows.

$$2MnO_4^- + 16H^+ + 5Sn^{2+} \longrightarrow 2Mn^{2+} + 8H_2O + 5Sn^{4+}$$

(i) Write a balanced equation for the reaction between Zn and Sn^{4+}.

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(ii) Use the *Data Booklet* to calculate the $E^\ominus$ values for the reactions between

- Zn and Sn^{4+}, ...
- MnO_4^- and Sn^{2+}.. .....

(iii) Use the results of the two titrations to calculate

- the number of moles of Sn^{2+} in the first titration sample,

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- the number of moles of Sn^{2+} in the second titration sample.

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(iv) Use the results of your calculation in **(iii)** to deduce the Sn^{2+}/ Sn^{4+} ratio in the oxide **A**, and hence suggest the formula of **A**.

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[8]

(e) A major use of tin is to make 'tin plate', which is composed of thin sheets of mild steel electroplated with tin, for use in the manufacture of food and drinks cans. A tin coating of 1.0×10^{-5} m thickness is often used.

(i) Calculate the volume of tin needed to coat a sheet of steel 1.0 m × 1.0 m to this thickness, on one side only.

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(ii) Calculate the number of moles of tin that this volume represents.
[The density of tin is 7.3 g cm^{-3}.]

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(iii) The solution used for electroplating contains Sn^{2+} ions. Calculate the quantity of electricity in coulombs needed to deposit the amount of tin you calculated in **(ii)**.

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[4]

[Total: 19]

3 Iron metal and its compounds are useful catalysts in certain reactions.

(a) **Apart from its catalytic activity**, state **two** properties of iron or its compounds that show that it is a transition element.

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.....[2]

(b) You are provided with a solution of $KMnO_4$ of known concentration in a burette.
Outline how you could use this solution to find out the concentration of $Fe^{2+}(aq)$ in a solution. You should include relevant equations for any reactions you describe.

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.....[4]

(c) For each of the following equations, write the oxidation number of the element printed **in bold** underneath its symbol, and balance the equation by adding appropriate numbers before each species.

(i) ..... $\mathbf{Mn}O_4^-$ + ... $\mathbf{S}O_2$ + ... $H_2O \rightarrow$ ..... $\mathbf{Mn}^{2+}$ + ... $\mathbf{S}O_4^{2-}$ + ... H^+

oxidation numbers: ....

(ii) ..... $\mathbf{Cr}_2O_7^{2-}$ + ... $\mathbf{N}O_2$ + ... $H^+ \rightarrow$ ..... $\mathbf{Cr}^{3+}$ + ... $\mathbf{N}O_3^-$ + ... H_2O

oxidation numbers: ....

[6]

(d) Outline the role that Fe^{3+} ions play in catalysing the reaction between iodide ions and peroxydisulfate(VI) ions.

$$2I^- + S_2O_8^{2-} \longrightarrow I_2 + 2SO_4^{2-}$$

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.....[2]

[Total: 14]

4 Sulphur and its compounds are found in volcanoes, in organic matter and in minerals.

Sulphuric acid, an important industrial chemical, is manufactured from sulphur by the Contact process. There are three consecutive reactions in the Contact process which are essential.

(a) Write a balanced equation (using ⇌ where appropriate) for **each** of these reactions **in the correct sequence**.

1 .....

2 .....

3 ..... [4]

(b) What catalyst is used?

..... [1]

Hydrogen sulphide, H_2S, is a foul-smelling compound found in the gases from volcanoes. Hydrogen sulphide is covalent, melting at –85 °C and boiling at –60 °C.

(c) **(i)** Draw a 'dot-and-cross' diagram to show the structure of the H_2S molecule.

(ii) Predict the shape of the H_2S molecule.

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(iii) Oxygen and sulphur are both in Group VI of the Periodic Table.

Suggest why the melting and boiling points of water, H_2O, are much higher than those of H_2S.

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..... [4]

Hydrogen sulphide burns with a blue flame in an excess of oxygen to form sulphur dioxide and water.

(d) (i) Write a balanced equation for the complete combustion of H_2S.

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(ii) What is the change in the oxidation number of sulphur in this reaction?

from ..... to .....

(iii) What volume of oxygen, measured at room temperature and pressure, is required for the complete combustion of 8.65 g of H_2S? Give your answer to two decimal places.

[5]

Hydrogen sulphide is a weak diprotic (dibasic) acid. Its solution in water contains HS^- and a few S^{2-} ions.

(e) (i) What is meant by the term *weak acid*?

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(ii) Write an equation, with state symbols, for the **first** ionisation of H_2S when it dissolves in water.

..... [3]

[Total: 17]